APPENDIX F
EIIP RECOMMENDED APPROACH TO USING THE DATA ATTRIBUTE RATING SYSTEM (DARS)

This page is intentionally left blank.

DARS BASICS

The Data Attribute Rating System (DARS) was originally developed as a research tool for rating national and global greenhouse gas inventories. The theoretical basis of DARS is described in Beck et al., 1994. EIIP has made some changes in the original system based in part on the results of several pilot studies. State agency personnel were trained in the DARS method, and then used DARS to rate their base year State Implementation Plan (SIP) ozone precursor inventories. In addition, particulate matter (PM-10) inventories (state and national levels) were evaluated by inventory developers trained in the use of DARS. The experiences and recommendations of field testers were incorporated in the version of DARS presented here. Key changes from the original are:

1. Rating criteria have been expanded to include point and mobile source emission estimation methods. The original DARS was developed for area source-type methods.

2. The definitions of the attributes have been made more specific. In particular, the full range of emission estimation methods and source types found in a state or regional inventory have been taken into account.

3. The assignment of scores within an attribute have been made less flexible. It is important that the scoring system not be too rigid because the inherent uncertainty in emissions varies among source types. Therefore, a method that is considered poor in most cases may actually produce very good estimates in certain other cases. An example is the use of mass balance. If the emissive process is the result of complex chemical reactions, mass balance produces a rough approximation. If the process is a simple physical one (e.g., evaporation), mass balance is a much more acceptable method.

4. The original DARS had five attributes, the EIIP version has four. Two attributes--measurement and pollutant specificity--were combined. This change actually improves the discriminating power of DARS because the pollutant specificity attribute was nearly always the same value in SIP-type inventories.

The DARS score is based on the perceived quality of the emission factor and activity data. Scores are assigned to four data attributes: measurement/method, source specificity, spatial congruity, and temporal congruity. A key feature of DARS is that these attributes are orthogonal; that is, they are independent of each other, and therefore the score for each attribute is independent of the other scores. However, the emission factor and activity scores for a given attribute are not necessarily independent. This is because the choice of one is usually limited by the selection of the other. For example, if a per capita factor is being used to estimate architectural surface coating emissions, then the activity must be population.

Table F-1 shows a DARS scoring box. The procedures for filling in the scores for emission factors and activity are described below. The emissions scores for each attribute (i.e., the right-hand column of the box) are computed by first dividing each score by 10, and then multiplying the factor score times the activity score. The composite scores for factor, activity, and emissions (i.e., the bottom row of the box) are computed by averaging the scores in a column. Scoring of each attribute is discussed below with specific examples. In general, the following guidelines should be used:

1. The specific scores and descriptions shown in the attribute scoring flow charts (Figures F-1 through F-8) are to be used as set-points. Users can interpolate between the values shown.

2. The scores are shown on a 1 to 10 basis, although the final scores are always less than 1 because the scores are divided by the maximum possible score of 10. In general, it is easier to think and talk in terms of 1 to 10, so that convention is used in the following descriptions and examples. However, the composite scores shown are always presented as fractions.

3. For the beginner, a good approach to selecting a score is to start at the beginning of the flow chart and work down to find the lowest number that most nearly fits the situation. Then adjust up to factor in other considerations (examples are given in later sections).

4. In the absence of sufficient information on the derivation of factors, activity, or emissions, choose the highest score that can be confidently made with the information provided. If the source or derivation of the data is totally undocumented, the highest possible score is 1. (One objective of DARS is to encourage good documentation of inventory data.)

DARS Scores Using Statistical Correlations

Many of the DARS attributes are scored based on presumed correlations between the target category and a surrogate. Unfortunately, very few of these correlations have been demonstrated statistically. If a statistical correlation is available, the correlation coefficient (usually expressed as r or sometimes R) can be used to help determine the DARS score. However, statistical correlations should be used very carefully. The data should apply directly to the region and source category being scored. Also, the data should be adequate and a representative sample should be chosen.

TABLE F-1

DARS SCORING BOX

Attribute	Factor	Activity	Emissions
Measurement/Method	e_1	a_1	$e_1 * a_1$
Source Specificity	e_2	a_2	$e_2 * a_2$
Spatial Congruity	e_3	a_3	$e_3 * a_3$
Temporal Congruity	e_4	a_4	$e_4 * a_4$
Composite	$\frac{\sum_{i=1}^{4} e_i}{4}$	$\frac{\sum_{i=1}^{4} a_i}{4}$	$\frac{\sum_{i=1}^{4} (e_i * a_i)}{4}$

The spatial and temporal attributes deal with scaling issues (in part). For example, many area source emission factors are based on annual national consumption that is then apportioned using population or employment. If the inventory uses daily emissions in a county, uncertainty is introduced by scaling down. If the activity and emissions are very uniform, then the uncertainty is low (and the DARS score relatively high). But many emissive activities vary in nature and importance geographically; in this case, using a national factor (or a mean value) will result in over- and underestimates of emissions at a small scale (i.e., at the county level).

Note that the same spatial concerns apply when scaling up. If the emissions from a small number of facilities are used to estimate emissions for the entire region, the representativeness of those sources in the entire population is important.

No formal relationship between DARS attribute scores and statistical variability or correlation measures has been developed. Unfortunately, it has not been the practice to publish statistical measures of emission factor variability in the past, although this is changing.

ASSIGNING ATTRIBUTE SCORES

Measurement/Method Attribute

The key to correctly scoring this attribute is to remember that it deals explicitly with measurement. The score is based on the quality of the factor itself--not on how it has been used (that is covered in the next section under source specificity). The presumption is that the best results are usually obtained by direct measurement of either emissions (either by source testing or continuous emission monitors [CEMs]) or by measurement of surrogate parameters that have a strong, statistically documented correlation with the pollutant of interest. The term "factor" is appropriate even when source testing was used because emission measurement data are usually expressed per unit of time. If a concentration is measured, the emissions per unit of time must be calculated for use in an inventory, or the original data may be expressed based on fuel consumed (or other variable). Figures F-1 and F-2 show the flow chart decision process used to score this attribute.

Very often, *AP-42* or other emission factors are used to estimate emissions. If possible, the appropriateness of the test data used to develop the factor should be studied to determine the DARS score. Alternatively, the default DARS scores for *AP-42* factors shown in Table F-2 can be used for point source estimates.

Area source emission factors are treated the same as point source factors when scoring this attribute. It is very unlikely that an area source emission factor will receive a score of 10 for this attribute. A 9 is possible if a large number of samples covering a representative portion of the source were used to develop the factor.

Some additional comments are warranted for emission factors based on mass balance. As seen in Figure F-1, this method can get a score varying from 3 to 5 depending on the source types and thoroughness. However, the score may be pushed even higher for some types of sources and if endpoints (other than air) have been fully quantified. For example, evaporative losses from solvent use can be reliably estimated using this method, provided that accounting for all the nonemissive losses is done. It seems reasonable to assume that volatile compounds will evaporate. The problem is that for surface coatings or graphic arts, some solvent may remain in the substrate. Some solvent may also be released to publicly owned treatment works (POTWs) or, if released inside a building, it may be absorbed by living tissue (e.g., plants or lungs of animals). For all of those reasons, the scorer is allowed to exercise some judgment. If there is some empirical basis for the mass balance factor (and especially if some of these other sinks for the solvents have been included in some way), the score can be raised to a 5 for area sources; higher scores may be given for point sources.

Figure F-1.
DARS Measurement Attribute Emission Factor Rating Flow Chart

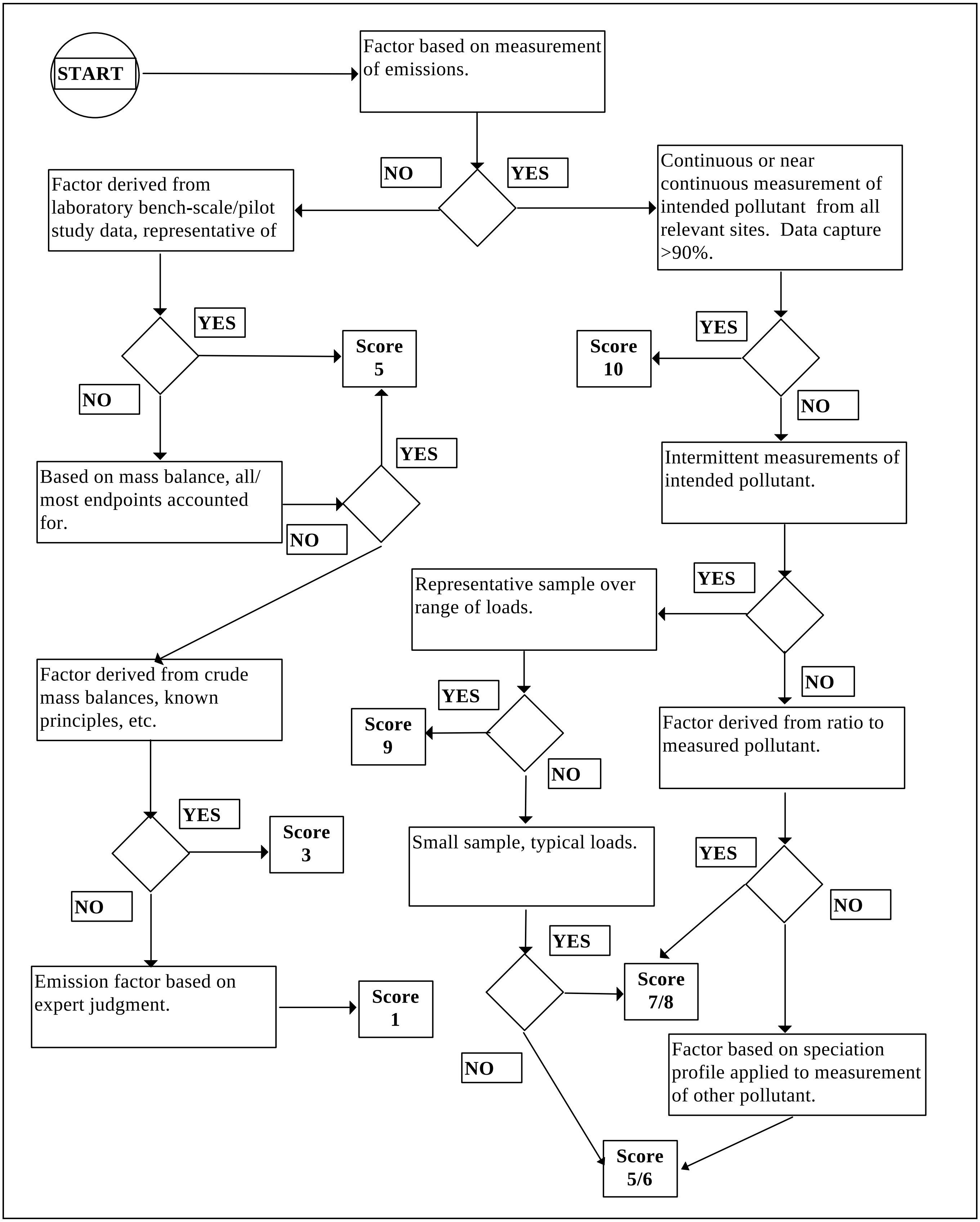


Figure F-2.
DARS Measurement Attribute Activity Rating Flow Chart

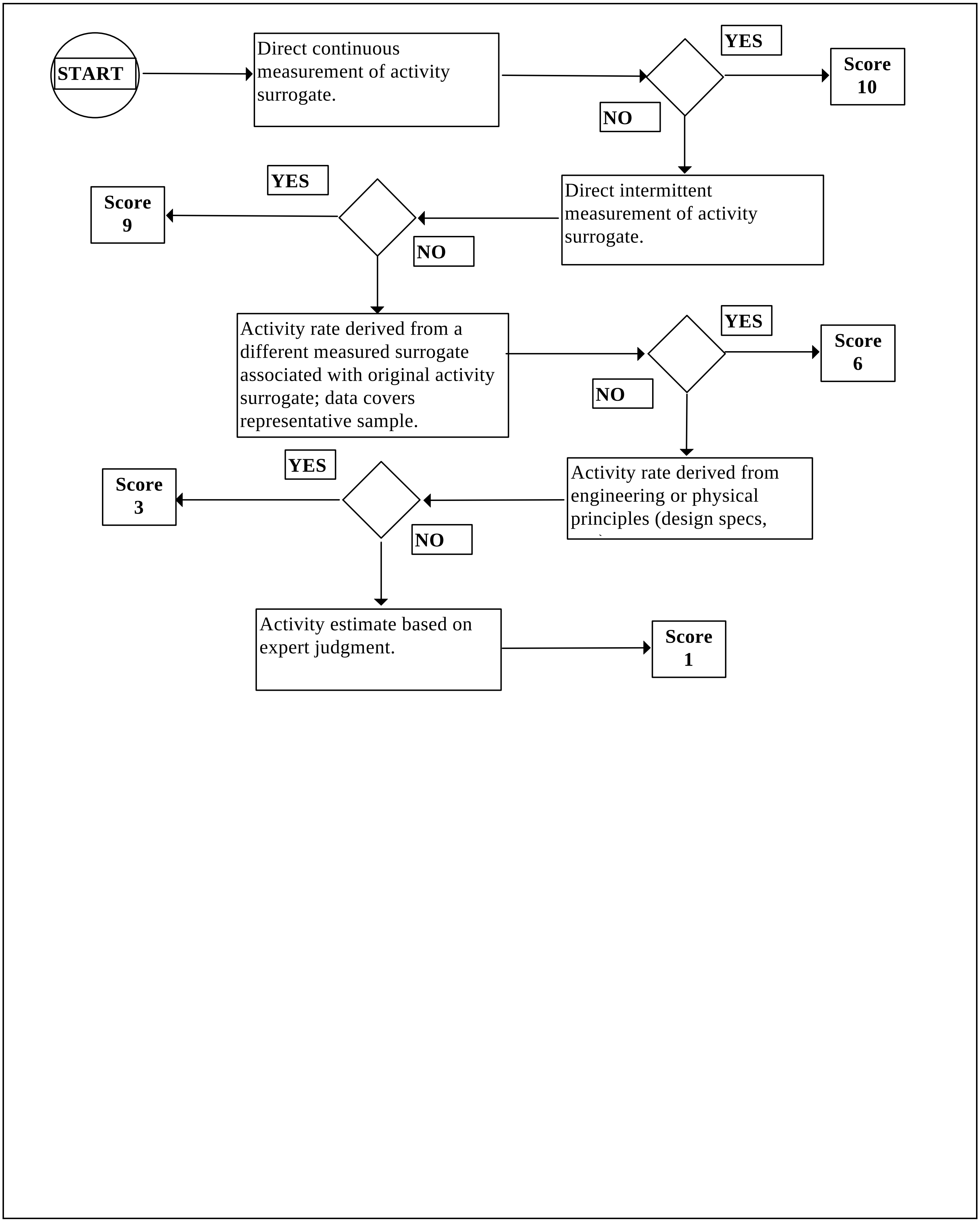


TABLE F-2

AP-42 LETTER CODES AND CORRESPONDING DARS FACTOR MEASUREMENT ATTRIBUTE SCORES

AP-42 Factor Rating	Pollutant Factor			
	NO_x	CO	VOC	PM-10
A	6	6	5	5
B	6	6	5	5
C	5	5	4	4
D	5	5	4	4
E	4	4	3	3

A 10 will rarely be given for the emission factor measurement score; however, they will be fairly common for the activity measurement score in point source inventories. For example, fuel use by a boiler is usually known for an industrial site and, assuming no uncertainty or gaps in the data, will receive a 10. Total county-wide fuel use by small boilers may not be directly measured, or may be difficult to obtain. A common source of state-level data is the *State Energy Data Report Consumption Estimates* (published annually by the U.S. Department of Energy or DOE); the methods used to compile these data are discussed in the technical appendices in that volume, and some known sources of errors are acknowledged. Generally, the values are based on either sales data (which is a surrogate, so this gets a score of 6 if the correlation is good), or shipments (by weight or volume) that might be construed as a direct intermittent measurement (and assigned a score of 8 or 9). The correct score will generally fall between 5 and 9 for this example.

If the oil is being consumed by industry other than in boilers, it is probably for heaters or other combustion devices. If no adjustment is made for these other uses, the DARS score is a 7. If the other uses have been subtracted from the total (or are known not to be important), the potential score can be raised to 8. If the DOE *State Energy Data Report Consumption Estimates* is the source of fuel oil consumption, then the highest possible score is an 8 given the uncertainties in the DOE method.

The two other fuels commonly included in the combustion source categories are natural gas and coal. The distinction between the industrial/commercial sectors used by the gas industry is not consistent with the definitions used by EPA (the gas industry definition is not based on Standard Industrial Classification [SIC] codes). Unless adjustments have been made to the data (based on state information, for example), the DARS score is a 5 for industrial or commercial natural gas combustion. Coal use by industry falls somewhere in between the natural gas and fuel oil DARS sources. The DOE reports that these are the most uncertain numbers because it is difficult to track at a state level. So, there is the potential for error in allocating national coal consumption to states (this comes into play when scoring the spatial congruity attribute). The allocation to industrial uses (versus commercial or residential) is pertinent to the measurement attribute; it is also difficult to track, but because very little coal is used by any sector other than utilities and industry, it is generally safe to assume that nonutility users are primarily industrial. The best possible score for coal is a 7.

Source Specificity

The source specificity attribute concerns how specific the original factor or activity surrogate is to the source being estimated. This attribute is easily confused with the previous one. The key point to remember is NOT to be concerned with whether or not the emission factor or activity is measured; the question to ask is "was this emission factor (or activity parameter) specifically developed for this source category?" To answer this question will require a clear definition of the source category and a good understanding of the source of the emission factor and activity parameter. Figures F-3 and F-4 provide the details needed to score this attribute.

It is common practice to borrow emission factors from similar processes if none are available for the intended source category. For example, no emission factors are available for small industrial reciprocating engines (SIREs) less than 250 hp, so it is common practice to use the factors intended for SIREs in the range of 250-600 hp. Using the rating flow chart shown in Figure F-3, the factor score in this example falls between 5 and 8. If nothing is known about the relative variation in engine emissions (particularly as related to size), the only option would be to choose the low score of 5. However, if standard references (such as *AP-42*) are being used, it is usually possible to find additional information. For example, if we compare the nitrogen oxides (NO_x) emission factor for a SIRE to that for a large bore engine (LBE), the ratio is 4.41 to 3.1 or roughly 1.4. If the same relationship can be assumed to apply to the smaller SIREs when compared to larger SIREs, then the variability is not likely to be high (where high is an order of magnitude or more). The score could be raised to 6. In most cases, the expected variability values and ranges shown on Figure F-3 will be subjective rather than actually quantifiable.

Figure F-3.
DARS Source Category Specificity Attribute Emission Factor Rating Flow Chart

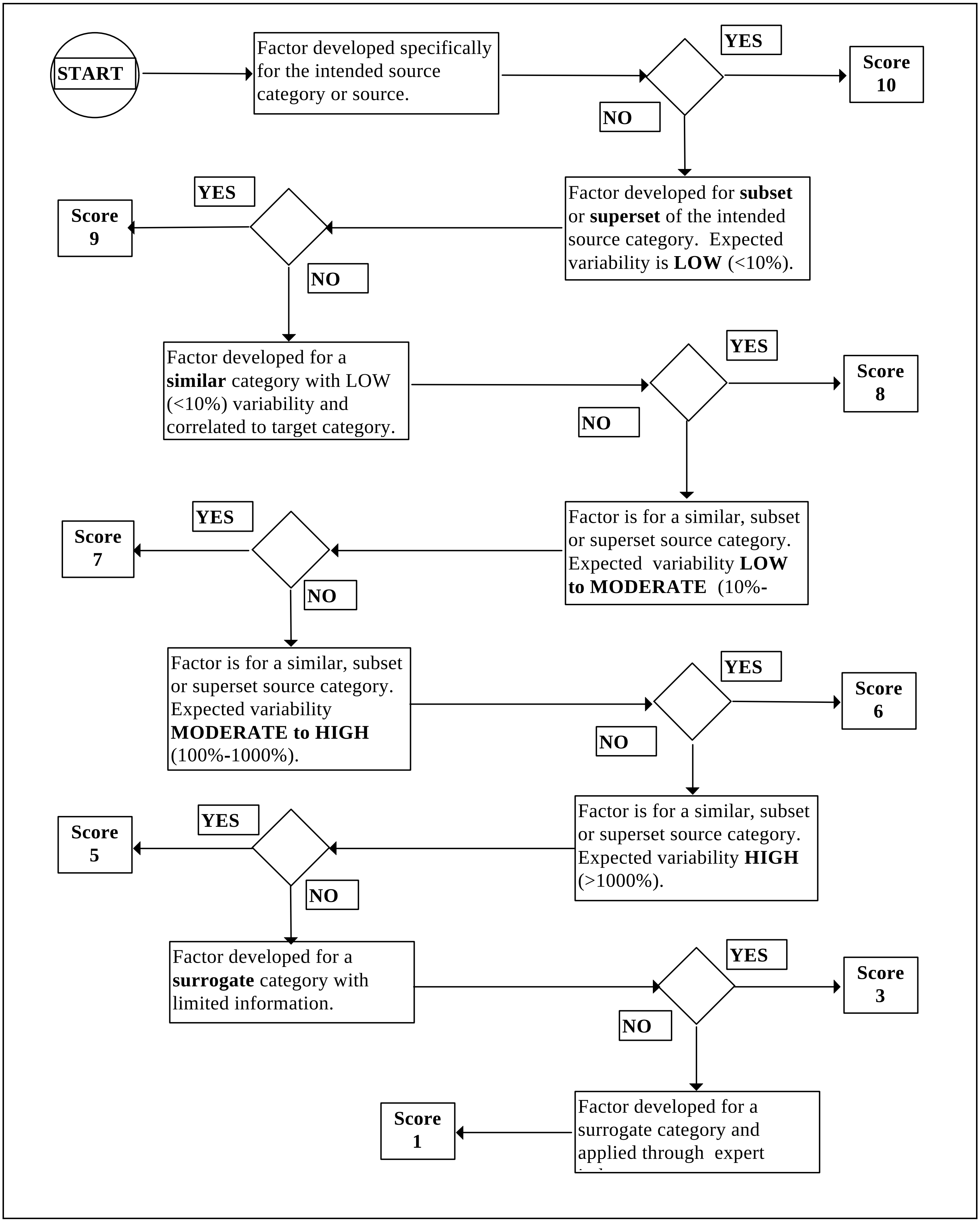
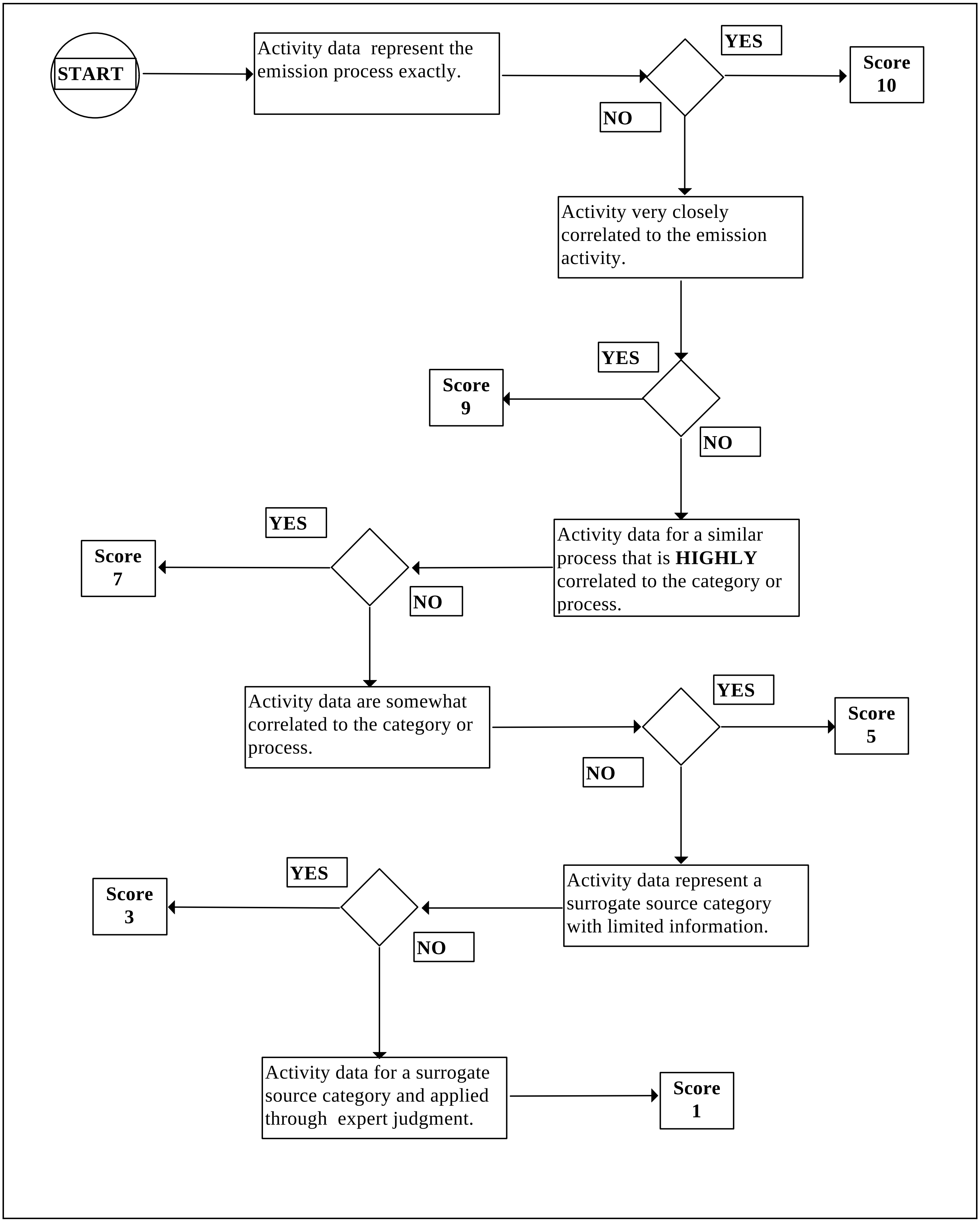


Figure F-4.
DARS Source Category Specificity Attribute Activity Rating Flow Chart



The activity score for this attribute is determined by the denominator in the emission factor. Scoring should be based on how *specifically* that activity variable applies to the emissive process. The use of annual industrial fuel oil consumption to estimate combustion area source emissions from industry provides a good example. Oil consumption is a surrogate for oil combustion, but it is a very good surrogate (activity source specificity attribute score is 9).

Very often, area source methods use an easily obtained surrogate variable as the activity variable. Commonly, population or employment data are used. The use of population as a surrogate will usually be scored as 1. However, if the inventory preparer (or provider of the emission factor) can demonstrate statistically a correlation between population and a specific activity, the score could be raised. One exception is consumer/commercial solvent use where population could reasonably be expected to correlate with product usage and therefore with emissions. This would still only get a 3 because other demographic factors (e.g., age, gender, ethnic background) are likely to affect types and quantities of products used.

Many adjustments to the factor should be included in scoring this attribute. These include rule effectiveness and rule penetration as well as others that are determined by the definition or characteristics of the source. Accounting for adjustments to estimates is discussed in the section entitled "Adjustments to Estimates." The main point is that any adjustments that improve the match between source category and factor or activity adds to the DARS score.

Spatial Congruity Attribute

This attribute deals with the spatial scaling of factors and activity data that is common to inventories. Figures F-5 and F-6 show the criteria used to score this attribute. For example, in the previous section, the use of state-level DOE fuel consumption data was discussed. With the exception of utilities' fuel consumption, sector fuel use by state is not measured directly. Various databases and assumptions must be used to allocate national fuel use to state level.

Furthermore, to use the state data at a county level, some method of apportionment must be used. Typically, the ratio of county industrial employment to state industrial employment is used. Unless there are studies demonstrating a correlation between employment and emissions, an activity score of 3 is indicated. The activity in this case is representative of a larger scale, and the scaling factors are not correlated well with activity. If information or data can be used to verify or adjust the scaled data, the score can be increased. A lot of judgment is required for scoring this attribute.

Spatial scale considerations should include instances where emissions or activity from the same scale are adapted for use in another region. An example is the use of non-road mobile

Figure F-5.
DARS Spatial Scale Attribute Emission Factor Rating Flow Chart

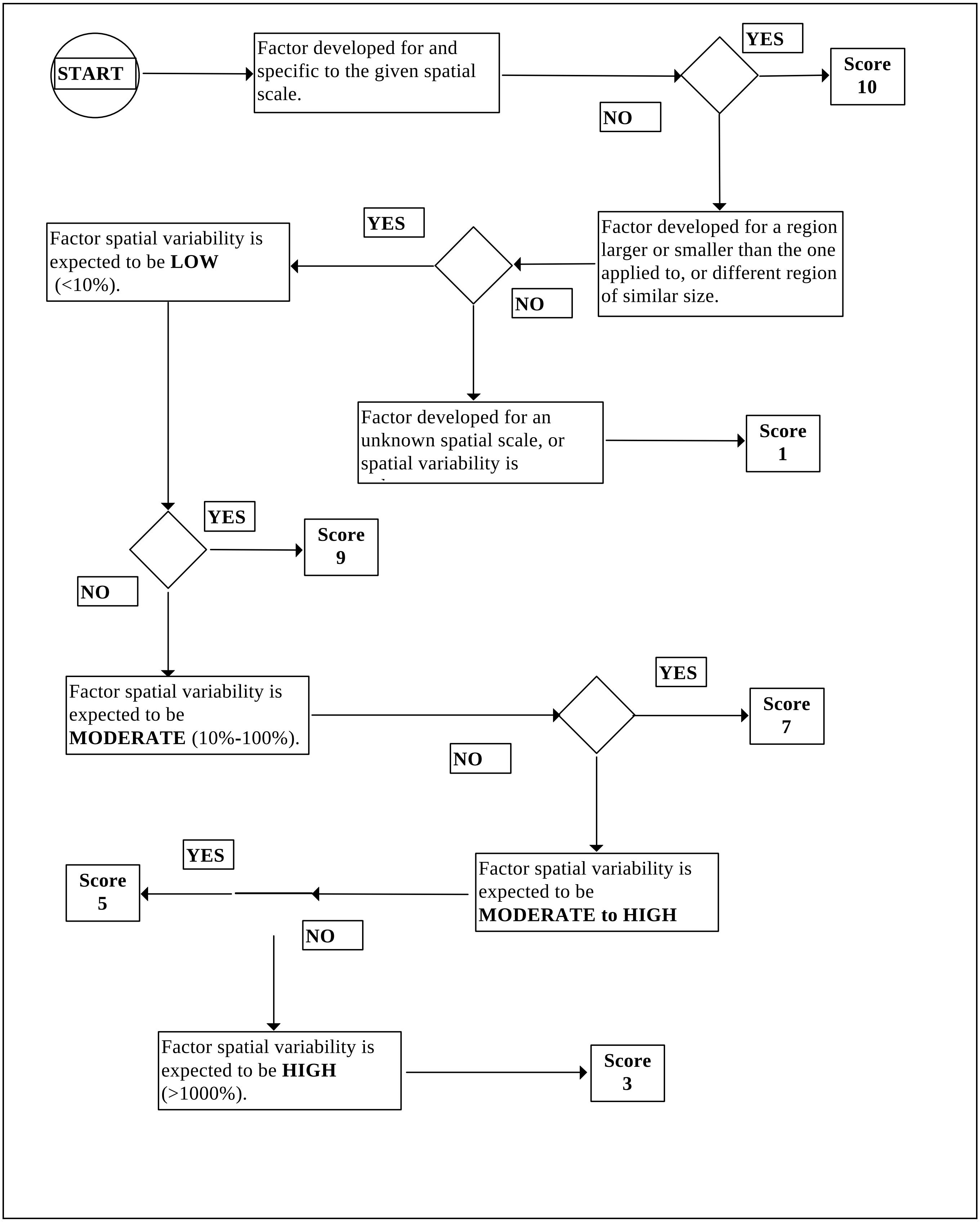
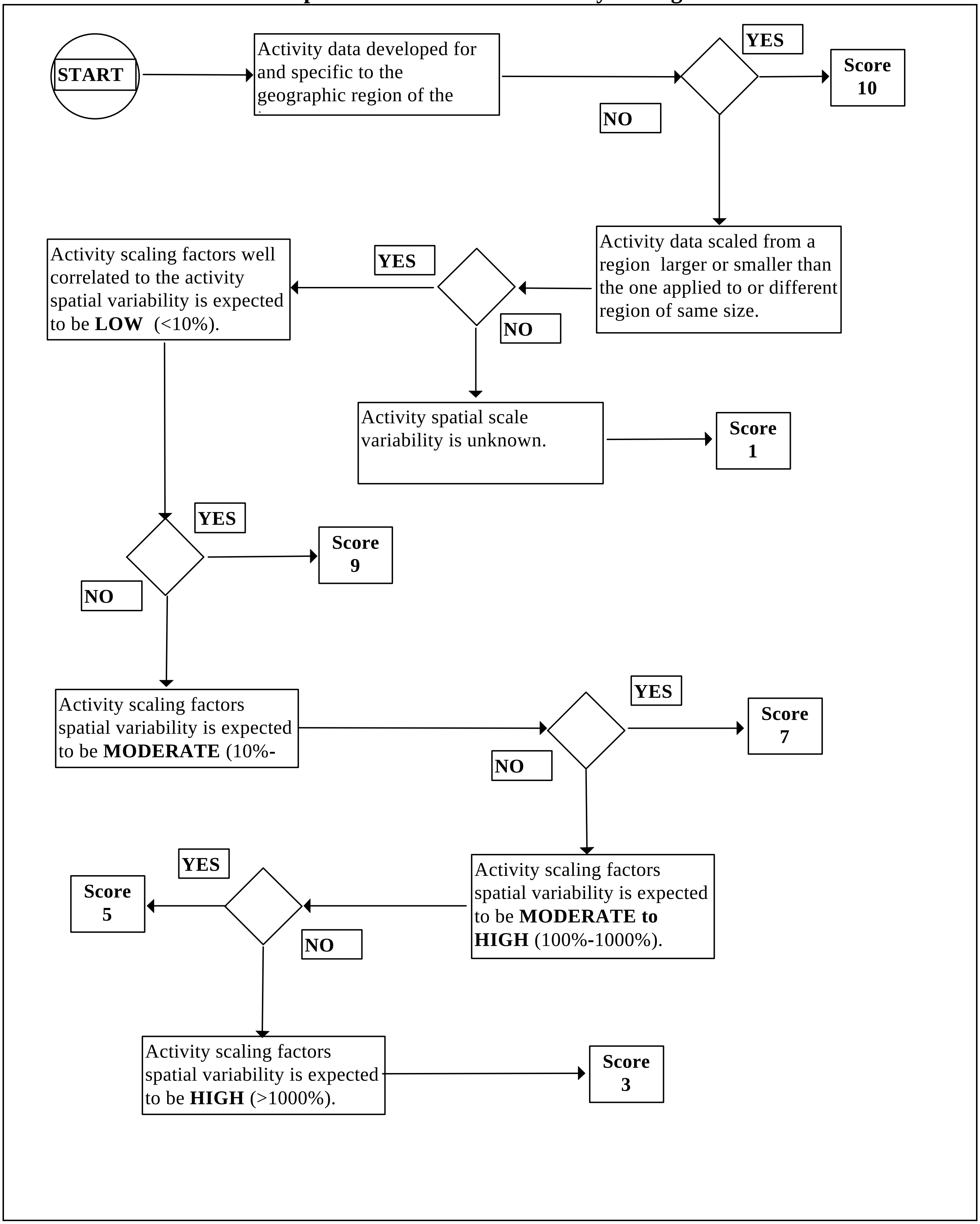


Figure F-6.
DARS Spatial Scale Attribute Activity Rating Flow Chart



emission studies for specific metropolitan areas applied to other metropolitan areas. Activity scores will typically fall between 3 and 7 in this example, depending on how well matched the two areas are. Clearly, if some additional work has been done to make the data match the intended source region better, that should be reflected in the DARS scores.

The variability in the emission factor that is caused by spatial scaling problems is easy to confuse with Source Specificity issues. For this attribute, regional or local variability in emissions that are attributable to climate, terrain, or other physical (environmental) factors is included. For example, evaporative losses of volatile organic compounds (VOCs) are affected by temperature. The emission factor equations for evaporative losses from petroleum product storage and distribution allow for adjustments based on local meteorological data. If these adjustments have not been made, and if the potential error is high, the DARS score is 3. However, if local conditions are not very different from the values used to calculate default emission factors, the DARS score could go as high as 8.

Temporal Congruity

This attribute describes the match between emission factor, activity, and temporal scale of the inventory. The scoring criteria are shown in Figures F-7 and F-8. The potential mismatches between an inventory estimate and the data used to calculate it that are included in this attribute are:

1. Emission factor or activity based on annual totals used to estimate hourly emissions.

2. Emission factors or activity based on short-term measurements are extrapolated to longer time frames.

3. Emissions projected into the future based on estimates of future growth.

The guidance for DARS scoring here is probably the most subjective of any of the attributes. The approach to use is:

1. Determine if there are any temporal incongruities for the source categories (such as those described above).

2. Evaluate the likelihood that these incongruities have the potential to affect the emissions.

There is no simple answer here. Some processes are fairly constant from year to year, and fairly uniform throughout the year. Others change dramatically from year to year, and may

Figure F-7.
DARS Temporal Attribute Emission Factor Rating Flow Chart

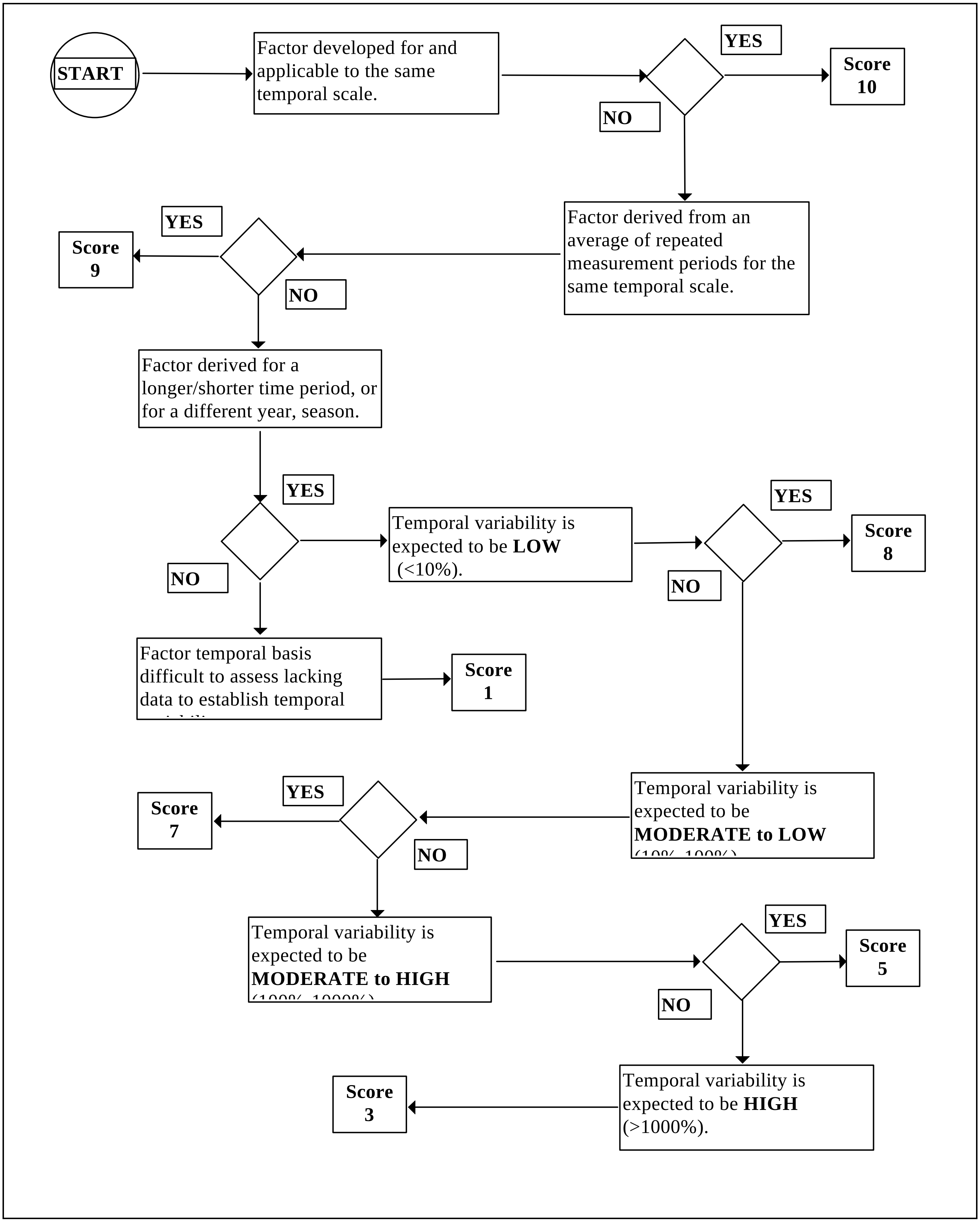
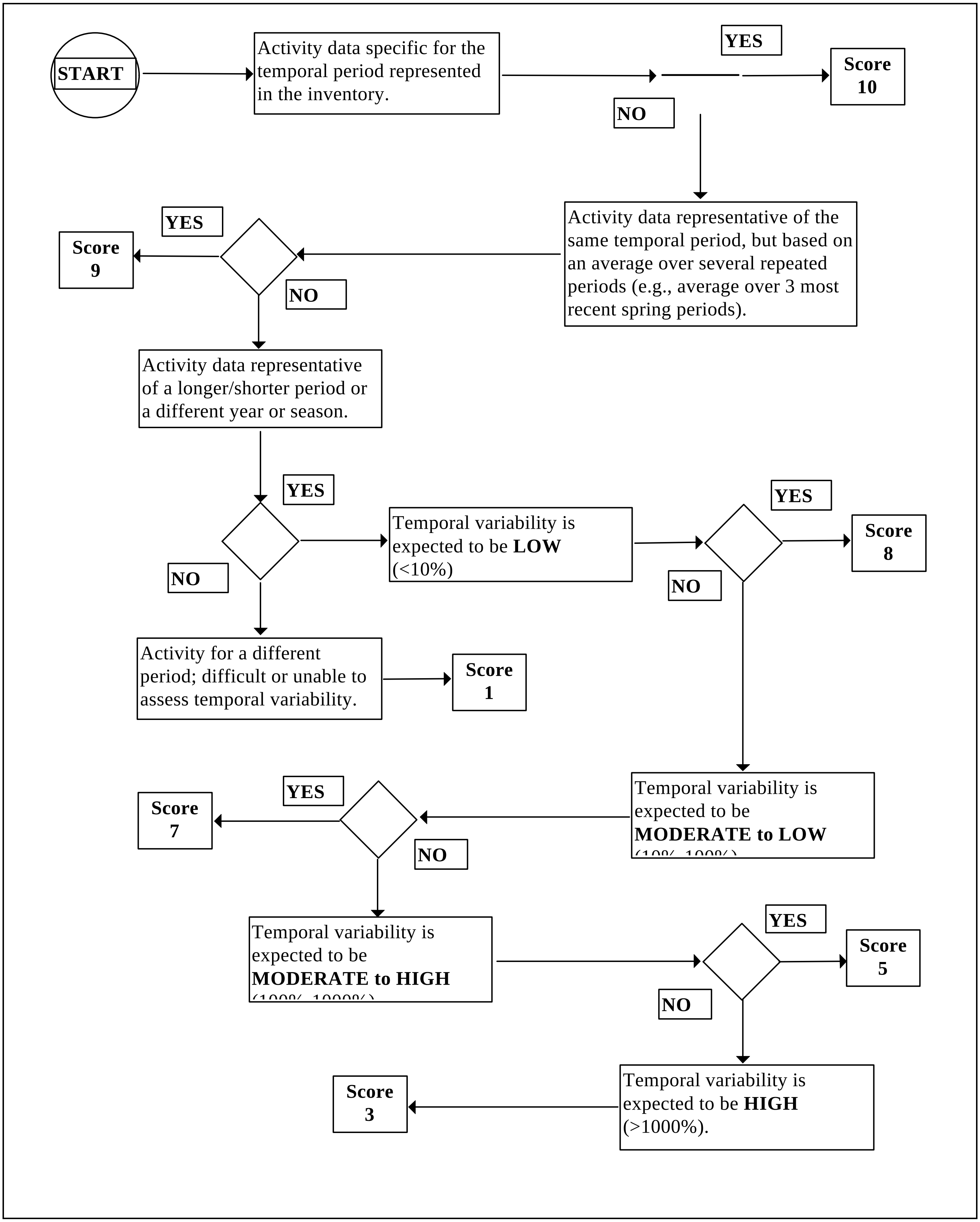


Figure F-8.
DARS Temporal Attribute Activity Rating Flow Chart



fluctuate widely throughout the year.

Activity in many industries fluctuates with demand for their products. These facilities do not necessarily reduce employment; instead, the plant may shut down for a few weeks, or they may go to shortened work weeks. Emissions estimated using per employee factors will not necessarily reflect this reduction in activity.

If the DARS scorer has reason to believe any of these issues (and others) apply to a source category, the DARS scores should be kept in the 3 to 5 range. As with spatial congruity, considerable judgment is required unless actual data are available.

Comparison of Measurement and Source Specificity Attributes

Some additional guidance is needed to clarify how the measurement and source specificity attributes are scored for both the emission factor and the activity:

- The source specificity attribute for the activity applies to the original choice of activity variable used when the factor was developed; for example, using "lb of coating" as the activity for architectural surface coating emissions would receive a higher source specificity score than using "population."

- The measurement attribute for the activity applies to the actual data used to estimate emissions in the inventory being scored; if population is required by the emission method chosen (i.e., a per capita factor is being used), and if population is measured directly, a score of 10 is possible. If coating consumption is being used, but had to be estimated, a score lower than 10 will be given.

For the emission factor scores, it is important to keep in mind that it is the *numerator* in the factor that you should consider. This may require some research to determine how the emission factor was developed. The general approach when developing a factor is to first quantify emissions from the source, and then to express the emissions in terms of some commonly available variable that is directly related to the emissive activity itself. The original emissions (i.e., the numerator in the factor) were probably expressed in terms of time and space (e.g., VOCs/day/spray booth, NO_x/year/globally). Two very different examples of emission factor derivations are given as examples:

- Company XYZ’s coal-fired boiler emissions might be estimated using cumulative NO_x emissions from the boiler’s CEM data over 1 year’s time; emissions are expressed as "tons NO_x emitted from XYZ’s boiler annually."

- Total VOCs from architectural surface coating use might be estimated by collecting national paint and coatings consumption data in 1 year, determining the average VOC content of those coatings, and assuming that all VOCs evaporate. The emissions might be expressed as "tons VOCs emitted from the use of architectural surface coatings in the United States annually."

In both cases, the temporal interval is 1 year, but the spatial scales are quite different. Either could be used to develop an emission factor.

The best factors are expressed in terms of a variable that is directly or indirectly related to the emissive activity itself. However, sometimes convenience is weighted more heavily, and a less-well-correlated surrogate (such as population) is used. Using the previous examples:

- Company XYZ's total coal use for the year is divided into the total NO_x emissions to develop an emission factor. The units of the factor are "tons of NO_x per ton of coal consumed."

- The VOCs from architectural surface coating are divided by the total national population. The units of this factor are "tons of VOCs per capita per year."

(Note that neither factor conveys any information about their original spatial scales. The NO_x factor also does not give any indication about the original temporal scale of the data.)

When assigning a DARS score for the emission factor measurement attribute, only the original emissions data should be rated. The denominator (i.e., the activity) is rated using the activity source specificity attribute. Figure F-9 illustrates this; the boxes that are applicable to the original emission factor data are shaded. This means that *no matter how poor the activity surrogate is, the emission factor measurement score will be a 10 if the factor is based on valid, near-continuous data.* This is illustrated using the NO_x example.

Consider the following emission factors, all developed using the continuous CEM data described above:

- lb NO_x/ton coal burned;
- lb NO_x/hours of operation;
- lb NO_x/rated capacity of boiler; and
- lb NO_x/boiler.

For each of these, the DARS emission factor measurement attribute is a 10. The activity source specificity score for the first is a 9 (at least), for the second is a 6, for the third is a 3, and for the last one is a 1. This approach suggests that a partial DARS score could be used

Attribute	Factor	Activity
Measurement		
Source Specificity		
Spatial		
Temporal		

FIGURE F-9. ATTRIBUTE SCORES BASED ON ORIGINAL FACTOR SHOWN AS SHADED BOXES

to rank emission factors (irrespective of how they are later applied). If DARS becomes a standard tool used by the states and EPA, the partial DARS scores could be supplied with the factor. EIIP guidance has already started to use this approach.

ADJUSTMENTS TO ESTIMATES

Some inventories require certain adjustments to the emission estimates or to the data used in the estimates. These adjustments may be prescribed for certain types of inventories (e.g., rule efficiency in SIP inventories). Or, they may be applied after the inventory was created to make it suitable for a new use (e.g., allocation of emissions to a grid for modelling purposes). Table F-3 lists some of these adjustments and shows which attribute score is affected. A brief description of each type of adjustment and its potential effect on DARS scores is given below. The reason for mapping an adjustment to a particular attribute may not always be apparent; in fact, some of the pairings are debatable. However, it is more important that the effect of an adjustment be accounted for only once, and that it be done consistently.

Control Efficiency (CE) and Rule Effectiveness (RE)

RE is an adjustment to CE that is used to account for deterioration, improper maintenance, or other factors that lower the effectiveness of control equipment. The use of RE affects the DARS emission factor source specificity score in the following ways:

1. If RE is *not* used at all, the base score is lowered unless justification is provided to show that RE is not applicable;

TABLE F-3

DARS ATTRIBUTES AFFECTED BY INVENTORY ADJUSTMENTS[a]

Adjustments	Measurement/ Method		Source Specificity		Spatial Congruity		Temporal Congruity	
	e	a	e	a	e	a	e	a
Control efficiency (CE)			X					
Rule effectiveness (RE)			X					
Rule penetration (RP)				X				
Speciation profiles	X							
Seasonal activity factors								X
Allocation to grid cell (modeling inventory)						X		
Subtraction of point sources from area		X						
Projections (or backcasting) of emissions	---[b]	X	---[b]	---[b]				

[a] e = emission factor score; a = activity score.
[b] One or more of these sources may be impacted (see text).

2. If RE has been calculated specifically for the source in the inventory region, the base score is either unchanged or may be raised (default is no change); and

3. If the EPA's default RE has been used, the base score is either unchanged or may be lowered (default is no change).

The decision to raise or lower a score is situation-dependent. For example, if the base DARS score source specificity factor score is already high (9 or 10) or very low (1 to 3), developing a source-specific RE value may have little effect on user confidence in the estimate. On the other hand, ignoring RE completely should produce some doubt about the estimate.

The reason that source specificity and not measurement/method is affected is that the measurement/method score is always based on the quality of the original factor. The way in which the factor has been applied is addressed in the source specificity attribute.

Rule Penetration (RP)

RP represents the fraction of the source population that is affected by a rule. The activity parameter is adjusted using RP, so it is accounted for in the DARS score for the activity source specificity attribute. This attribute score is affected as follows:

1. If a control requirement exists but RP is not addressed, lower the score at least one point.

2. If RP is included (where appropriate), the base score is unaffected or possibly raised if inclusion of RP has a significant impact on the estimate.

The decision to raise or not raise the score is situation-dependent.

Speciation Profiles

The use of speciation profiles to estimate a specific pollutant type (e.g., specific hazardous air pollutants, PM-2.5) from a more general pollutant category (e.g., VOCs, PM) is accounted for in the emission factor measurement/method score. Generally, the method used to estimate the general pollutant is scored first; the application of a speciation profile usually results in lowering the score. However, if the speciation profile can be shown to be very accurate, the effect on the score may be minimal.

Seasonal Activity Factors (SAFs)

SAFs are often used to adjust an annual value to a daily or seasonal estimate. Because it is usually more accurate to estimate a short-term value using data appropriate to that time period, using an SAF will negatively impact the activity temporal congruity score.

Allocation to Grid Cell

Modelling inventories for area or mobile sources are often prepared by allocating emissions to grid cells; the resulting inventory is more finely resolved (spatially) than the original inventory. Any impact on emissions certainty is accounted for in the activity spatial congruity attribute because allocation is usually achieved by adjusting the activity variable.

Point Sources Adjustment to Area Sources Emissions

Certain types of processes may be represented by both point and area sources. Typically, the activity factor is adjusted by subtracting any point source activity from the total activity before calculating the area source emissions. This should be considered when scoring the activity measurement/method attribute.

Projections (or Backcasting) of Emissions

If emissions at some future date are needed, they must be estimated by projecting into the future. Determining the DARS score for projection inventories will generally be a two-step process. First, determine the scores for the inventory used as the basis for the projections. Second, modify the attributes affected by the use of growth factors.

Usually, the activity measurement/method attribute is adversely affected by projections because the activity is "grown" by some multiplier. However, in some circumstances, more than one attribute will be impacted. In an example using utility boilers, forecasts may predict an increase in energy demand in the inventory region. This percentage of increase in demand may be used to "grow" the utility emissions from the base year. This approach assumes that the base year proportions of processes (e.g., coal, oil, hydroelectric, solar) will not change and, furthermore, that the emission factors for those processes will not change. If these assumptions cannot be confidently made, the DARS score for emission factor measurement/method and for activity source specificity may be lowered (from the base year's) to reflect the decreased confidence in the estimate.

A current example is any industry using paints or coatings that is subject to one of the new National Emission Standards for Hazardous Air Pollutants (NESHAPs) developed since the 1990 Clean Air Act Amendments were passed. These proposed Maximum Achievable Control Technology Standards (MACT) and Control Techniques Guidelines have resulted in significant changes in coatings formulations. These reformulated products are already in use and will increase in use over the next few years. Changes in the formulations will result in changes in emissions that will not be predictable. However, once all affected facilities are in compliance, the emissions per unit activity should be more consistent from facility to facility. Using a 1990 emission factor to estimate future emissions will not produce reliable results.

DARS: POINT SOURCES

Although DARS was originally conceived as an application for global inventories developed using area source inventory methods, not as an application for point sources, the method can be applied to inventories at any scale. However, the amount of time required to assign DARS scores to an entire point source inventory for just one county can be quite high. Even if simplified methods (as described below) are used, scoring an entire point source inventory will nearly always require more effort than required for the area and mobile source inventories.

Point source inventories are generally expected to be "better" (which usually is assumed to imply "more accurate") than area source inventories. Although the activity data are certainly likely to be more accurate, the same cannot be said for the emission factors. In fact, emission factors are usually based on a small sample of individual units in the source category. Using these factors to estimate emissions from *another* individual emission unit has a higher probability of error than using it to estimate the sum of emissions of units (i.e., an area source approach). This occurs because an average factor will either under- or overestimate the emissions about half of the time. However, summing up these individual estimates tend to cancel out the errors. (Note that according to this argument, the sum of the point source emissions is "better" than the individual estimates.)

Another problem with emission factors, however, is that they may be based on a biased data set. (The example cited earlier for SIREs applies here.) If the emission factor is based on a subset of the technologies covered by the source category, the factor may in fact be misapplied (or at best a tenuous match) to units not represented in the original data set.

For these reasons and others, it is generally not productive to evaluate every emission unit within a facility, or even every facility, individually, if the overall objective is to rate the point source inventory. An easier (and just as accurate) approach is to sort the point source inventory emissions into categories based on methods used, e.g., source testing, *AP-42* factors, state factors, mass balance, and engineering judgment. Then, sort each of these categories by the method used for the activity data (fuel/materials consumption, production rate, hours usage).

DARS scores are then applied to these groups of sources rather than to individual sources. The scorer may want to spend more time on sources where source testing or nonstandard methods are used. Also, keep in mind that mass balance used at an individual facility may be more accurate than when used to develop a national estimate. If other losses (i.e., non-air releases) are accurately accounted for, the DARS activity measurement score could reach a 9 (and possibly 10 if well supported).

Keeping the above comments in mind, the general guidance given for area sources will apply to point sources. For a given source type (e.g., industrial fuel consumption), if *AP-42* emission factors are used, the measurement attribute score will be the same as for area sources. The scores for the other attributes will usually be different.

As stated above, several different approaches can be used to apply DARS to a point source inventory. If a comparison of individual facilities is needed, each point source must be evaluated separately, applying DARS scores to each emission unit (or collection of similar units). The individual scores are then weighted by the percentage contribution to total facility emissions. A more common approach is to assess the point source inventory overall, rather than dealing with individual point sources. Sources are grouped in some logical way (such as by Source Classification Code), and DARS scores are assigned to those groupings. An example using this approach is shown in the next section.

APPLICATION OF DARS TO RICHMOND, VA, POINT SOURCE INVENTORY

In this inventory, five different estimation methods were used to estimate emissions for point sources (Ballou, 1995). These methods and the rationale for the DARS scores are discussed in the following subsections in order from highest to lowest composite emissions score.

Continuous Emissions Monitoring

This method is generally considered the best method for emission estimates if the associated data quality and coverage goals are met. However, no estimate is 100% accurate and a margin of equipment downtime or data loss is allowed when accepting this type of data. As a result, a score of 9 was applied to the measurement attribute to reflect this. This could be raised or lowered if actual coverage and completeness data were available. If monitored correctly, all other scores could achieve scores of 1.0. In the case of this inventory, there were no estimates based on this method.

Attribute	Factor	Activity	Emissions
Measurement	0.9	0.9	0.81
Specificity	1.0	1.0	1.0
Spatial	1.0	1.0	1.0
Temporal	1.0	1.0	1.0
Composite	0.975	0.975	0.95

Source Stack Testing

This is the next highest-rated method for developing emission estimates. However, because most stack test data used for inventories come from compliance tests based on small samples running "typical" loads, lower scores were assigned to the measurement attribute. Lower scores were also assigned to the temporal attribute since it is likely that the factor and activity data are based on different time periods or seasons/years. A small number of emission estimates in the inventory were based on stack test results.

Attribute	Factor	Activity	Emissions
Measurement	0.8	0.9	0.72
Specificity	1.0	1.0	1.0
Spatial	1.0	1.0	1.0
Temporal	0.8	0.8	0.64
Composite	0.9	0.925	0.84

Mass Balance Calculation

In a deviation from the DARS flow charts, mass balance calculations were assigned a higher score for evaporative and/or process emissions at point sources. This was done assuming that all losses are accounted for as part of these calculations. A substantial number of VOC estimates in the inventory were based on mass balance calculations as well as a lesser amount of process NO_x emissions.

Attribute	Factor	Activity	Emissions
Measurement	0.7	0.9	0.63
Specificity	1.0	1.0	1.0
Spatial	1.0	1.0	1.0
Temporal	0.8	0.8	0.64
Composite	0.875	0.775	0.8175

Source-specific Emission Factors

For this evaluation, source-specific emission factors were rated a step above *AP-42* factors but below the methods already discussed. The reason for this is that these factors are derived from source-specific information, based on other more accurate estimation methods (stack tests and mass balance) or tests made on similar equipment elsewhere. Therefore, source specificity and the overall score is slightly lower for this reason. Relatively few estimates were based on these types of calculations.

Attribute	Factor	Activity	Emissions
Measurement	0.7	0.9	0.63
Specificity	0.8	1.0	0.8
Spatial	1.0	1.0	1.0
Temporal	0.8	0.8	0.64
Composite	0.825	0.925	0.7675

AP-42 Emission Factors

The official *AP-42* emission factors, and the computerized factors based on *AP-42* are rated at this point in the hierarchy of methods. The major dilemma in assigning a single DARS score to *AP-42* factors is the variation in the quality of the factors. To try to address this quality variability, different scores were assigned to the measurement attribute factor rating based on the factor rating in *AP-42* (if available). This was an easier task in the case of NO_x because the *AP-42* factors are generally combustion related, well documented, and of better quality. This was much more difficult for VOC factors that had little or no documentation of quality, and had no ratings in many cases. When no rating could be found, the lowest score was assigned. The scores assigned were based on the information shown in Table F-2.

Attribute	Factor	Activity	Emissions
Measurement	0.4 to 0.6	0.9	0.36 to 0.54
Specificity	0.7	1.0	0.7
Spatial	1.0	1.0	1.0
Temporal	0.8	0.8	0.64
Composite	0.725 to 0.775	0.925	0.675 to 0.72

Expert Judgment/Guess

For obvious reasons, this method of emission calculation is ranked lowest because of the lack of any information on the data and calculations used to make such estimates. A small number of emission estimates were developed using this method.

Attribute	Factor	Activity	Emissions
Measurement	0.1	0.8	0.08
Specificity	0.6	0.8	0.48
Spatial	1.0	1.0	1.0
Temporal	0.7	0.7	0.49
Composite	0.6	0.825	0.51

These scores were then applied to the source emissions at the process level. The DARS scores for each process were multiplied by the relative contribution of that process to *total* point source inventory emissions to produce a weighted DARS score. An example for two sources is shown in Table F-4. The sum of these weighted emissions is the overall DARS score for the inventory. In this example, the composite DARS score for the NO_x inventory was 0.76; for the VOC inventory, 0.72.

APPLICATION OF DARS TO COMPLEX MODELS

Emission inventories are not usually thought of as models, but in fact they are. A model is a representation of reality. In an emission inventory, the model may be as simple as

emissions = emission factor x activity

Or, a complex, computer-based model may be used to estimate the emission factor, the activity, or both. The same guidance given previously in this appendix for simple models (i.e., emission factor x activity) can be applied to the use of more complex models such as those used to estimate mobile source emissions.

One factor to be considered when rating complex emission factor models is whether the model is based solely on theory (i.e., first principles). Theoretical models generally rate a 3 for the measurement attribute factor score (see Figure F-1). If the model has been validated or calibrated using real-world measurements, the model results are considered better. Empirical models (e.g., statistical regressions) are not necessarily better or worse than theoretical or deterministic models. In both cases, the degree to which key explanatory variables have been included and the amount of variability reduced affect the quality.

A key point to keep in mind is that *increased model complexity does not necessarily imply better quality emission factors*. If default input values are used to estimate an emission

TABLE F-4

EXAMPLE OF 1990 POINT SOURCE DARS EVALUATION FOR NO_x (RICHMOND OZONE NONATTAINMENT AREA)

Plant Name	Emissions	% of Total	DARS Score	Weighted Score
Facility 1	95.15	0.000329	0.72	0.00023739
	2685.27	0.009304	0.72	0.00669958
	0.8	0.000002	0.72	0.00000199
	2270.52	0.007867	0.72	0.00566480
	86.35	0.000299	0.72	0.00021543
	0.6	0.000002	0.72	0.00000149
	2420.04	0.008385	0.72	0.00603785
	91.85	0.000318	0.72	0.00022916
	0.8	0.000002	0.72	0.00000199
	1846.72	0.006399	0.72	0.00460750
	70.4	0.000243	0.72	0.00017564
	0.6	0.000002	0.72	0.00000149
	2404.08	0.008330	0.72	0.00599803
	91.3	0.000316	0.72	0.00022778
	0.8	0.000002	0.72	0.00000199
	55	0.000190	0.72	0.00013722
	0.2	0.000000	0.72	0.00000049
	56.1	0.000194	0.72	0.00013996
	0.2	0.000000	0.72	0.00000049
	57.2	0.000198	0.72	0.00014271
	0.06	0.000000	0.72	0.00000014
	486.66	0.001686	0.675	0.0011383
	217.25	0.000752	0.675	0.00050814
	159.47	0.000552	0.675	0.00037300
Facility 2	161.2717	0.000558	0.6975	0.00038978
	6175.324	0.021398	0.6975	0.01492558
	6815.7	0.023617	0.72	0.01700475
	16.32	0.000056	0.675	0.00003817
	16298.25	0.056476	0.72	0.04066312

Plant Name	Emissions	% of Total	DARS Score	Weighted Score
	16.8	0.000058	0.675	0.00003929
	36635.85	0.126950	0.72	0.09140418
	34.56	0.000119	0.675	0.00008083
	62202.75	0.215544	0.72	0.15519201
	68.64	0.000237	0.675	0.00016054
Facility 3	0.66	0.000002	0.72	0.00000164
	105.374	0.000365	0.675	0.00024647
	6	0.000020	0.5125	0.00001065
Facility 4	101.2	0.000350	0.72	0.00025248
	484	0.001677	0.72	0.00120755
	14.72	0.000051	0.675	0.00003443
	422.4	0.001463	0.72	0.00105386
	2051.5	0.007108	0.72	0.00511836
	37.95	0.000131	0.675	0.00008876
	4	0.000013	0.72	0.00000997
	4	0.000013	0.72	0.00000997
	583	0.002020	0.8175	0.00165151
	11	0.000038	0.84	0.00003201
	126	0.000436	0.84	0.00036675
	29	0.000100	0.84	0.00008441
	23	0.000079	0.84	0.00006694
	6434	0.022295	0.84	0.01872783
	291	0.001008	0.84	0.00084703
	823	0.002851	0.84	0.00239555
	12229	0.042375	0.84	0.03559569
	12817	0.044413	0.84	0.03730722
	15806	0.054770	0.84	0.04600749
	10360	0.035899	0.84	0.03015548
	8903	0.030850	0.84	0.02591450
	4640	0.016078	0.84	0.01350593

factor, the resulting computer model-generated factor may be no better than a national average factor based on measurements or mass balance; if, however, site-specific input data are used, the emission factor produced by the model is of better quality than the default.

For the modeled emission factor, most of the effort will focus on the measurement attribute score. However, for some models such as MOBILE5a that provide national default inputs, the spatial congruity attribute should be carefully evaluated as well. If specific local inputs were used, the spatial congruity score for the factor may rate as high as 10. If national defaults were used, the score will be lower.

When scoring the measurement attribute for an emission factor or activity developed using a model, ask the following questions:

Step 1. Is the model entirely theoretical? This means it has never been validated or calibrated using real-world data, and no empirical measurement data were used in developing the model equations. If yes, then the factor measurement attribute score is 3; if no, go to Step 2.

Step 2. Were some parts of the model based on empirical data, either limited field data, or laboratory or bench-scale data? If yes, do these "parts" have a significant impact on the model results? If no, the score may be raised slightly, but not greater than 4.

If yes, go to Step 3.

Step 3. Has significant real-world validation/calibration of the model been done and has this demonstrably improved the model's capability to produce accurate emission factors? If yes, have these capabilities been used by the inventory developer to their maximum capability? If no, do not increase the score any higher. If yes, the score may be raised as high as 9 (but only if the model has been demonstrated to be highly accurate and its full potential has been used).

If a model is used to calculate activity, the same considerations apply. For example, travel demand modules may be used to calculate vehicle miles travelled (VMT) for a mobile source inventory. The first step is to determine a score for source specificity: how good a surrogate is VMT for combustion of fuel in an internal combustion engine? This score does *not* consider how VMT was calculated. Developing the measurement score requires consideration of the quality of the model.

By now, it should be clear that the scores for complex models are assigned using essentially the same criteria as for any area source. Furthermore, no matter how complex the model, the relevance of its results with respect to real-world data must be demonstrated in order for higher scores to be achieved.

REFERENCES

Ballou, T., R.L. Peer, and V. Chandler. 1995. *Evaluation of an Inventory Rating System: An EIIP QAC Project*. Presented at the Air & Waste Management Association's Emission Inventory Conference, Research Triangle Park, North Carolina.

Beck, L., R. Peer, L. Bravo, and Y. Yan. 1994. *A Data Attribute Rating System*. Presented at the Air & Waste Management Association's Emission Inventory Conference, Raleigh, North Carolina.